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# **Cormorant Food Habit and Potential Impacts on Sport and Commercial Fisheries: An Annotated Bibliography**

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Office of Migratory Bird Management  
Arlington, Virginia**

**February 2000**

This list includes literature on the double-crested cormorant that contains: (1) qualitative or quantitative descriptions of food habits, or (2) qualitative or quantitative information on the impacts of cormorant predation on fish populations. The latter category includes papers that discuss the various bioenergetics variables that may be used in simulation models to assess impacts on prey populations.

[1835](#) ✓

Audubon, J. J. 1835. **Ornithological bibliography**. Edinburgh.

Lewis (1929) quotes Audubon to the effect that "the food of double-crested cormorants consisted of 'shrimps, lents, capelings, codlings, and other fishes.' It was his [Audubon's] opinion that 'of the codlings especially they devour vast numbers,' but recent investigations have not confirmed this."

[1890](#) ✓

Warren, B. H. 1890. **Report on the Birds of Pennsylvania**. E. K. Meyers, Harrisburg, Pennsylvania. 434 pp.

Author notes (pp. 28-29) that a specimen of a fish (known locally as "buffalo-sucker") taken from the stomach of a bird collected by James Thompson near Erie on 26 October 1889 measured 8-9 inches in length.

[1894](#) ✓

Curtis, C. P., Jr. 1894. **The double-crested cormorant**. Auk 11: 175.

"For the past ten years I have spent one day in the last part of September on the Graves at the entrance to Boston Harbor [Massachusetts, where] . . . I generally shoot four or five [double-crested cormorants] . . . and . . . I have . . . invariably found the throat of the bird full of fish, generally the common sea-perch."

Mackay, G. H. 1894. **Habits of the double-crested cormorant (Phalacrocorax**

**dilophus) in Rhode Island.** Auk 11: 18-25.

Fourteen pellets examined at Cormorant Rocks, off Seconnet Point, on 19 April 1892 were "composed almost entirely of fish bones, chiefly the bones of young parrot-fishes (Labroids) and drums (Sciaenoids)," while one pellet "contained three crabs (Cancer irroratus... [and] Panopeus sayi)." Five birds collected on the same date all had eels (Anguilla vulgaris) in their gullets; one bird contained an eel that was 16 inches long, while those in the other four birds were 7-11 inches long.

"Mr. Geo. A. Tapley of Revere, Mass., shot one of three [cormorants] (variety not noted [but presumably double-crested]) which were standing on the edge of a marsh in that place in the winter, at a time when there was much ice around. They were engaged in eating a sculpin (Cottus scorpius...)."

[1895](#) ✓

Chamberlain, C. 1895. **An inland rookery of Phalacrocorax d. albociliatus.** Nidologist 3: 29-30.

"Under the trees [containing double-crested cormorant nests at Clear Lake, Lake County, California, in March 1895] were pieces of carp dropped from above. Some pieces were from fish that must have been fifteen inches long. The carp constitutes probably the sole food of these cormorants."

[1904](#) ✓

Todd, W. E. C. 1904. **The birds of Erie and Presque Isle, Erie County, Pennsylvania.** Ann. Carnegie Mus. 2(4): 481-596. [p. 308]

S. E. Bacon reported that a double-crested cormorant collected near Erie on 14 December 1901 contained two 10 inch perch, and added that "The fishermen inform me that the birds when present often alight on the pond-net stakes."

[1908](#)

Chapman, F. M. 1908. **Camps and Cruises of an Ornithologist.** New York.

Chapman (p. 305) observed a perch lying on the ground among nests in a cormorant colony at Shoal Lake, Manitoba, in June 1901.

[1910](#) ✓

Ferry, J. F. 1910. **Birds observed in Saskatchewan during the summer of 1909.**

Auk 27: 185-204.

At a double-crested cormorant colony at Big Quill Lake in July, "The young appeared to be fed upon minnows, which they would sometimes disgorge in a semi-digested state when alarmed."

[1913](#) ✓

Wright, H. 1913. **The birds of San Martin Island, Lower California.** Condor 15: 207-210.

In describing a visit to this island in July 1913, Wright notes that "We became very much interested in estimating the amount of fish these birds [from a double-crested cormorant colony estimated at 348,480 nests] consumed per day. We noted the amount each young cormorant threw up when molested, and found on several occasions a bunch of fish as big as a man's two fists. This mass was generally composed of surf fish, smelt, and sardines. I have heard of other estimates of from three to six sardines a day for a cormorant, so I consider a half pound of fish a day very conservative."

[1915](#) ✓

Taverner, P. A. 1915. **The double-crested cormorant (Phalacrocorax auritus) and its relation to the salmon industries on the Gulf of St. Lawrence.** Canada Geol. Surv. Mus. Bull. 13 (Biol. Ser. 5), 24 pp.

Six fish species were identified in the 27 birds with food in their stomachs collected along the Gaspé Peninsula, June-July 1914, with sculpin, herring, flounder, and capelin being predominant. No salmon remains were found in cormorant stomachs.

"From all reports, the salmon in the rivers have been lately increasing from year to year. One experienced man says that ten or twelve years ago about thirty fish were taken in the York river per year, while in 1913 from 120 to 130 were caught by anglers. The cormorants are also generally increasing in number, the rookeries are enlarging and new ones being established. These facts taken together do not indicate that the cormorants are markedly harmful to the salmon..."

[1919](#)

Pearson, T. G., C. S. Brimley, and H. H. Brimley. 1919. **Birds of North Carolina.** North Carolina Geol. Econ. Surv. 4, 380 pp.

"The food of these cormorants must consist largely of eels, as eel remains are constantly found in the nests and on the limbs of the trees, and the young when

alarmed disgorge copiously fragments of partly digested eels. In the summer of 1905, H. H. Brimley saw an immature bird disgorge a portion of a large watersnake (Natrix taxispilota) [p. 49]."

[1922](#) ✓

Bent, A. C. 1922. **Life histories of North American petrels and pelicans and their allies.** U.S. Natl. Mus. Bull. 121, 343 pp.

"On the New England coast they are frequently seen flying up the larger rivers and tidal estuaries to fish, where they live largely on eels [p. 248-249]." Bent also quotes extensively from Mackay (1894) and Taverner (1915).

Jackson, H. H. T. 1922. **Some birds of Roosevelt Lake, Arizona.** Condor 24: 22-25. Three fish dropped by cormorants at nesting colonies in May 1916 included two carp (*Cyprinus carpio*) and one largemouth bass (*Micropterus salmoides*).

Stoddard, H. L. 1922. **Bird notes from southern Wisconsin.** Wilson Bull. 34: 67-79.

"The stomachs of seven adults shot April 10 [1921, along the Wisconsin River near Sauk City] all contained fish. Five each held one large bullhead of nearly a pound weight . . . while each of the others held a pike that would weigh over a pound. Others examined from time to time contained partly digested bullheads or more rarely other fish."

[1924](#) ✓

Howell, A. H. 1924. **Birds of Alabama.** Alabama Dep. Game and Fish., Montgomery, Alabama. 597 pp.

"Cormorants feed exclusively on fish: stomachs of two collected in the Mobile River each contained remains of two gizzard shad (Dorosoma cepedianum) about 10 inches long, and one stomach contained, also, part of the tail of an eel [p. 39]."

[1925](#) ✓

Uhler, F. M. 1925. **Report on the Economic Status of the Double-crested Cormorant (Phalacrocorax auritus auritus) and Other Fish-eating Birds in Minnesota and North Dakota.** Unpublished manuscript report to Chief, Bureau of Biological Survey, Washington, D.C.

[1926](#) ✓

Hall, E. R. 1926. **Notes on water birds nesting at Pyramid Lake, Nevada.** Condor 28: 87-91.

Fish disgorged by double-crested cormorant chicks on 26 July 1924 included 36 lake minnows (*Leucidius pectinifer*) and ten lake chubs (*Siphateles obesus*). One adult disgorged five lake minnows, each 5.5" long (Table).

[1927](#) ✓

Bailey, A. 1927. **Notes on the birds of southeastern Alaska.** Auk 44: 1-23.

"At Klawack [= Klawock], where they [double-crested cormorants] were fairly common [in March 1920], they were feeding upon the schooling herring, in company with other cormorants and gulls."

Munro, J. A. 1927. **Observations on the double-crested cormorant (*Phalacrocorax auritus*) on Lake Manitoba.** Canadian Field-Nat. 41: 102-108.

Munro provides information on nine prey items found in stomachs (n = 10) or regurgitations in July 1925, but the data are difficult to quantify in terms of frequency of occurrence or relative abundance. He states that: "The number of individual fish of different species found [regurgitated by cormorants] on the reefs was in proportion to their local abundance in the waters close at hand."

*Esox lucius*. Northern Pike. One 14 inch fish was found in one stomach, and seven fish (8-14 inches in length) were found regurgitated on nesting islands. This and the pickerel were the only commercially important fish taken, and Munro estimated that (in combination) these two species comprised one-third of the fish taken or 25% of the entire diet. Other species included: *Stizostedion vitreum*, pickerel; *Perca flavescens*, perch; *Stizostedion canadense*, sauger; *Moxostoma aureolum* or *Catostomus catostomus*, mullet; *Lota maculosa*, Ling; *Eucalia inconstans*, brook stickleback; *Notropis atherinoides*, lake shiner; *Notropis* spp., unidentified shiners; and unidentified crayfish.

Wetmore, A. 1927. **The amount of food consumed by cormorants.** Condor 29: 273-274.

Reports that double-crested cormorants of the Florida (*P. auritus floridanus*) race housed at the National Zoo "thrive and live in perfect health for years" on a diet of 0.75-1.00 lbs of fish/day, 6 days/week (not fed on Sundays).

[1929](#)

Lewis, H. F. 1929. **The Natural History of the Double-crested Cormorant (*Phalacrocorax auritus auritus* (Lesson))**. Ru-Mi-Lou Books, Ottawa, Canada.

Lewis (pp. 62-71) provides 13 quantifiable data sets on food habits, but only two of these represent analysis of 30 or more samples (stomachs or regurgitated pellets).

"In a letter dated December 3, 1928, Mr. Alexander Sprunt, Jr., of Charleston, South Carolina, states, concerning this bird in his vicinity: 'It is rather difficult to ascertain just exactly the scope of its feeding habits, but the following items of food are certainly represented: gizzard shad (*Dorosoma cepedianum*), sea catfish (*Felichthys felis* and *Galeichthys milberti*), mullet *Mugil cephalus*), common eel (*Anguilla chrysypa*), and an occasional shrimp (*Palemon vulgaris*).'"

"...Reuben Lloyd (*in lit.*, 1929) ...says that the food of the colony at the north end of Last Mountain Lake, Saskatchewan, consists chiefly of perch and pike [p. 69]..."

"The files of the Biological Survey contain additional records of the food of these birds in Minnesota, including the following items: *Perca flavescens* (yellow perch), *Abramis crysoleucus* (golden shiner), catfish, part of a beetle, and Centrarchidae that are probably *Lepomis megalotes* [p. 69]"

"Other records of the food of this species in the same state [Minnesota] include an anonymous statement (1921) in 'Fins, Feathers, and Fur', official bulletin of the Minnesota Game and Fish Department, that black bass, perch, and sunfish were found in stomachs of double-crested cormorants taken at Clearwater Lake, Minnesota, and the statement of Mr. P. O. Fryklund (*in lit.*, 1927) that he found many pike in a cormorant colony on Gull Rock, in that part of the Lake of the Woods belonging to Minnesota [p. 69]"

[1931](#) ✓

Munro, J. A., and W. A. Clemens. 1931. **Waterfowl in relation to the spawning of herring in British Columbia**. Biol. Board Canada Bull. 17, 46 pp.

The stomach of a double-crested cormorant collected in Departure Bay on 11 March 1929 contained the remains of one herring (p30).

[1932](#) ✓

Howell, A. H. 1932. **Florida Bird Life**. Florida Dep. Game and Fresh Water Fish. 597 pp.

"Examination of 72 stomachs of this species in the Biological Survey showed its food to be about 99 per cent fish, the remainder comprising crabs, shrimps, other crustaceans, and a frog. Thirty-six species of fishes were identified in the

stomachs examined, including sea catfish, horned pout, gizzard shad, herring, skipjack, sunfish, black bass, yellow perch, pigfish, spot, file fish, and toadfish" [p92].

McAtee, W. L. 1932. **Effectiveness in nature of the so-called protective adaptations in the animal kingdom, chiefly as illustrated by the food habits of nearctic birds.** Smithsonian Misc. Coll. 85(7), 201 pp.

In an analysis of 237,399 "identifications" of animals recorded in stomachs of 80,000 birds (of an unspecified number and composition of species) collected in nearctic America, 1885-1931, author tabulates relative abundance by family (pp. 111-120). Fifteen of the 54 families represented in 2,670 identifiable remains of fish had a relative abundance of >1%, and 10 of these occurred in significantly larger numbers than expected (indicated by \*): Siluridae 3.7%, Catostomidae 2.3%, \*Cyprinidae 18.0%, \*Dorosomidae/Clupeidae 9.3%, \*Engraulididae 1.9, \*Salmonidae 7.4%, \*Argentinidae 1.1%, \*Poeciliidae 19.8%, \*Gasterosteidae 4.2%, \*Centrarchidae 6.1%, \*Percidae 6.4%, \*Cottidae 7.0%, Gadidae 1.2%, and Pleuronectidae/Soleidae 1.1%.

"One double-crested cormorant had eaten 16 Symphurus plagiusa [a flatfish of the family Pleuronectidae; p118]."

Roberts, T. 1932. **The Birds of Minnesota. Volume 1.** Univ. Minnesota Press. 718 pp.

"Friends of the bird have tried to make it appear that the cormorant catches mainly rough fish of little value, but there is reliable evidence to show that it captures game-fish as well, if they chance to be in its way and it is able to run them down. Under their tree nesting-places, as at lake Minnetonka, may be found numerous fish that have been dropped by the young birds, and among them the writer has identified crappies, sunfish, small bass, and pickerel, as well as carp and bullpouts" [p. 171].

### 1936

Cottam, C., and F. M. Uhler. 1936. **The role of fish-eating birds.** Progr. Fish-Cult. 14: 1-14.

"Inland colonies [of the double-crested cormorant] are frequently condemned to an unwarranted degree although some of them undoubtedly cause destruction to valuable fish. Threat of complete destruction of one of the two remaining colonies in one of the north central states was made because local sportsmen believed the birds were responsible for the elimination of fish in a lake that formerly had afforded some of the best fishing in the state. A careful investigation revealed that excessive alkalinity of the water resulting from greatly lowered levels throughout a period of many years, made the production of any



valuable species of fish impossible in this lake. Stomach examination of a series of these birds collected there showed that 75 percent of the food consisted of the axolotl stage of the tiger salamander, 20 percent of bull-heads taken from an adjoining prairie slough, and the remaining 5 percent of the five-spined sticklebacks, which were the sole remaining fish capable of enduring the high alkalinity occurring in the lake."

Mendall, H. L. 1936. **The Home Life and the Economic Status of the Double-crested Cormorant (Phalacrocorax auritus auritus)**. Univ. Maine Stud. 2nd Ser. No. 38, Maine Bull. 39(3): 1-159.

#### 1940

Gabrielson, I. N., and S. G. Jewett. 1940. **Birds of Oregon**. Oregon State Coll., Corvallis, Oregon.

"Food of this cormorant consists very largely of fish and other aquatic life . . . . Although fishermen sometimes claim that it destroys large numbers of commercially valuable fish, examinations of some Oregon stomachs confirm our belief that trash fish comprise a large percentage of its diet. Two stomachs from Warner Valley each contained remains of one sucker (Catostomus warnerensis) [Table] One stomach from Tillamook Bay (taken May 20) contained seven or more Chitonotus pugetensis and remains of a few shrimp. Three stomachs contained pieces of two species of crustaceans, bits of grass, and a mass of fish remains, so digested as to be unidentifiable, that comprised 95% of the entire contents. Another stomach taken at the same time in Tillamook Bay contained the remains of six sculpins (Cotus asper), and another (taken January 1) contained remains of one Chitonotus pugetensis. Two other stomachs were practically empty and contained only tiny bits of fish bones and crustaceans [p97]."

Todd, W. E. C. 1940. **Birds of Western Pennsylvania**. Univ. Pittsburgh Press. 710 pp.

"S. E. Bacon speaks of having taken two ten-inch perch from the gullet of a bird that he shot at Erie, and adds that 'the fishermen inform me that the birds when present often alight on the pond-net stakes.' [p45]"

#### 1942

Bartholomew, G. A., Jr. 1942. **The fishing activities of double-crested cormorants on San Francisco Bay**. Condor 44: 13-21.

Bartholomew describes flock-feeding activities of cormorants during the winter of

1940-1941. "Mass fishing is an efficient way of obtaining food and a surprising number of cormorants return to the surface with fish in their bills... based on many hours of observation, I would suggest that one in every six or seven birds returning to the surface has a fish [NOTE: this implies a success rate of 14-17%]. The fish (possibly anchovies) caught in mass fishing seldom exceed five inches in length and many are required to furnish an adequate meal."

While Bartholomew reports concentrations of up to 1,500-2,000 birds, "Small flocks of fishing cormorants are more common than large ones and the flocks most frequently seen on the Bay contain fewer than twenty birds." "As a rule relatively fewer fish are caught by the members of the small flocks than by the members of the larger groups."

Twice within three minutes on 10 November 1940, exceptionally large fish were caught by a flock of 25 cormorants, with 1 bird surfacing with "a flounder about eight inches long."

"On February 8, 1941, while watching birds in the Berkeley Aquatic Park, Mr. [Herman V.] Leffler saw about ten double-crested cormorants . . . catching perch (size unspecified), some of which were pregnant."

"Since during most of the fall and winter of 1940-41 the number of cormorants in the central part of San Francisco Bay was about 2,000, they caught and ate approximately one ton of fish daily. Nevertheless, it seems improbable that these birds have any economic importance, for little commercial fishing is done on the Bay. Cormorants do not compete with sport fishermen because the only important game fish on the Bay is the introduced striped bass, and this fish is usually too large for the birds to handle."

"No effort was made to determine by an examination of stomach contents the kinds of fish eaten, but cormorants on San Francisco Bay have been seen catching smelt, founder, and pipe fish, and they probably will eat any fish of a reasonable size that they can catch."

#### 1944

Gross, A. O. 1944. **The present status of the double-crested cormorant on the coast of Maine.** Auk 61: 513-537.

#### 1945 ✓

Cottam, C., and F. M. Uhler. 1945. **Birds in Relation to Fishes.** U.S. Fish Wildl. Serv. Wildl. Leaflet 272, 16 pp.

In this revision of Cottam and Uhler (1937), the cormorant discussion remains unchanged from the original (Cottam and Uhler 1936).

[1947](#)

Baillie, J. L. 1947. **The double-crested cormorant nesting in Ontario.** Canadian Field-Nat. 61: 119-126.

In August 1946, the author visited a nesting colony in Georgian Bay where cormorants were said to be "detrimental to the black bass fishing... and to pound net fishing."

"We visited the only nesting rock then occupied by cormorants (McCoy Island) and an examination of the fish remains lying around the nests supported our conclusion that the local ranges of the bass and the cormorants did not overlap to any significant extent. At any rate, 17 of the 18 fishes examined at the nests were yellow and log perch, suckers and rock bass (all of them under six inches in length) and only one a small-mouthed black bass, 5 1/2 inches in length. The rest of the cormorants' larder was made up of 21 crayfish (mostly claws)... The perch, suckers, and rock bass are not important as sport fish. The black bass fishing, for which the... region is famous, was poor in 1945 and 1946, and it seems that the cormorants were made the scapegoats."

[1949](#) ✓

Sprunt, Jr., A., and E. B. Chamberlain. 1949. **South Carolina Bird Life.** Contrib. Charleston Mus. 11, Univ. South Carolina Press, Columbia, South Carolina. 585 pp.

"Food: Largely fish, about 99 per cent. Sea-catfish, gizzard shad, herring, skipjack, sunfish, and toadfish have been found in stomach contents. Shrimp, crabs, and other crustaceans are taken, and sometimes frogs [p. 74]."

[1950](#) ✓

Scattergood, L. W. 1950. **Observations on the food habits of the double-crested cormorant, Phalacrocorax a. auritus.** Auk 67: 506-508.

Of 35 cormorants collected in the Gulf of Maine (31 August and 2 October 1944, 22 July 1947, and 12 and 18 May 1949), 29 contained the remains of at least 10 species of fish. Sixty-seven regurgitations collected at a colony on Little White Island, Maine, in 1949 contained the remains of 305 individuals of 15 species of fish; four of the species had a relative abundance of greater than 10%.

[1951](#) ✓

Trautman, C. G. 1951. **Food habits of the double-crested cormorant.** South Dakota Conserv. Digest 18(11): 3-5 and 10.

A total of 157 food samples (147 regurgitants of young and 10 stomach contents of adults) were analyzed from colonies at four lakes, June-July 1949. Waubay and Traverse lakes contained a large variety of prey species, including both game and rough fish; Oakwood Lake had very few rough fish, but had been stocked with bullheads, perch, walleyes, northerns, bass, and bluegills; and Sand Lake was highly carp infested. "In summarizing the information obtained from this study, it seems quite clear that cormorants eat whatever is available rather than display any degree of preference for one or more particular fish species."

[1952](#) ✓

Farner, D. S. 1952. **The Birds of Crater Lake National Park.** Univ. Kansas Press. 187 pp.

"There appears to be little doubt that the fluctuation in numbers on Crater Lake is, at least in part, correlated with the status of the fish population. . . . Since accurate annual records of the fish taken from Crater Lake by anglers have been kept, it is possible, by using these data as a crude index of the fish population, to make an approximation of the relation between the populations of fish and cormorants [pp. 21-22]." Over the period 1937-1950, the average success rate of sport anglers in the five years in which cormorants were judged to be "abundant," "common," or "probably common" (0.6 fish/hour) was twice as high as in the five years in which cormorants were "uncommon," "rare," or absent (0.3 fish/hour); similarly, the average number of fish caught in years in which cormorants were abundant or common (2,838 individuals/year) was 13 times greater than in years in which cormorants were uncommon or rare (215 individuals/year).

[1953](#) ✓

McLeod, J. A., and G. F. Bondar. 1953. **A brief study of the double-crested cormorant on Lake Winnepegosis.** Canadian Field-Nat. 67: 1-11.

Of 9+ species found in regurgitations, only two (pickerel, *Stizostedion vitreum*, and goldeye, *Amphiodon alosoides*) were of commercial value, and these represented only about 7% (by weight) of the total consumption. The most abundant species in the diet were tullibee (*Leucichthys* spp.) and perch (*Perca flavescens*).

[1955](#) ✓

Durham, L. 1955. **Effects of Predation by Cormorants and Gars on Fish**

**Populations of Ponds in Illinois.** Ph.D. dissertation, Univ. Illinois, Urbana. 113 pp.

In July 1952, two wing-clipped cormorants spent 28 cormorant-days foraging in a 0.75 acre enclosure on a 7 acre pond in Ford County that contained bass and green sunfish. In July 1953, bass in the enclosure were 16% longer than bass in the unfenced portion of the lake (8.3 vs 7.1 in). Based on an assumption that each cormorant consumed 1.2-2.0 lb of fish/day, author estimates that they may have consumed 58-94% of the fish biomass in the enclosure.

At a 1.2 acre pond in Piatt County, a stunted population of green sunfish was significantly reduced in number and in maximum length (and growth-rate increased significantly) after being subjected to 202 cormorant-days of predation, suggesting selective predation on the larger sunfish (maximum = 7.8 in, median = 2.7 in). Goldfish grew faster in the year after cormorant predation than in any previous year.

Two years after receiving 51 days of predation by cormorants and 14 days of predation by a common merganser, the bluegills in a 1.9 acre pond in Piatt County were mostly of the same year class and showed no appreciable increase in average length. This finding is attributed to selective predation on the larger bluegills (maximum = 8.5 in, median = 3.8 in), with the smaller fish not reduced in numbers sufficiently to reduce intraspecific competition for food.

Lewis, H. F. 1956. **Report on Investigation of Complaints Against Cormorants in Nova Scotia.** Internal Rep., Wildl. Div., Dep. Lands and Forests, Kentville, Nova Scotia.

1957

Lewis, H. F. 1957. **Report on Investigation of Complaints Against Cormorants in Nova Scotia in 1957.** Internal Rep., Wildl. Div., Dep. Lands and Forests, Kentville, Nova Scotia.

1958 ✓

Behle, W. H. 1958. **The Bird Life of Great Salt Lake.** Univ. Utah Press, Salt Lake City. 203 pp.

"The author has made no thorough study of the food habits of our local birds, but casual observation of the few piles regurgitated owing to our presence indicate a diet primarily of carp with chubs, suckers, and minnows occasionally taken. On April 4, 1941, two carp (Cyprinus carpio) six inches long were seen at one nest and at another nest were ten silver side minnows (Richardsonius hydrophlox) that ranged from two to four inches long. On April 27, 1941, at one nest a sucker (Catostomus fecundus) eight inches long was found, and several carp

were seen on the ground between nests. On June 14, 1941, in addition to carp we found three small silver side minnows and four yellow perch (Perca flavescens). One catfish was regurgitated by a bird on June 8, 1947 [p. 137]."

#### 1962

Palmer, R. S. (Ed.). 1962. **Handbook of North American Birds. Vol. 1. Loons through Flamingos.** Yale Univ. Press, New Haven, Connecticut. 567 pp.

Palmer (p. 399) notes that identifiable fish in stomachs of four birds collected in July at "Fake Pass" (= False Pass), Alaska, included flounders, tomcod, and smelt. Palmer also summarizes the published literature on prey species found in the diet.

#### 1965 ✓

Bailey, A. M., and R. J. Niedrach. 1965. **Birds of Colorado, Volume 1.** Denver Museum of Natural History. 454 pp.

"The adults are good parents, feeding the youngsters by regurgitation with an abundance of fish, principally carp in Colorado, which they secure by diving [p91]."

#### 1967 ✓

Meister, A. L., and F. J. Gramlich. 1967. **Cormorant Predation on Tagged Atlantic Salmon Smolts. Final Report of the 1966-67 Cormorant-Salmon Smolt Study.** Unpubl. Admin. Rep., Maine Atlantic Sea Run Salmon Comm., Orono, Maine.

Owre, O. T. 1967. **Adaptations for locomotion and feeding in the anhinga and the double-crested cormorant.** Ornithol. Monogr. 6, 138 pp.

"Of three stomachs from cormorants collected in fresh water, one was empty and the other two contained fish. One contained partly digested remains of species of the Family Centrarchidae and a large spotted gar, Lepisosteus platyrhincus. The other contained remains of a large catfish, probably Ameiurus nebulosus marmoratus (Holbrook). I have often seen comorants surface in fresh water with centrarchids between their mandibles."

"The Lepisosteus record requires special comment. This gar was removed alive from the esophagus of a cormorant collected from a flock fishing in a large, flooded borrow-pit, the waters of which were heavily populated with gars. The remaining cormorants of the flock took off from the water, some with difficulty. The cormorant collected was apparently unable to become air-borne,

despite a long up-wind run. The Lepisosteus measured 449 millimeters in total length, 117 millimeters in girth, and had a weight of 201.8 grams. The weight of the cormorant, without that of the Lepisosteus, was 2030.3 grams.

Nine specimens collected in marine waters contained the remains of four species of bottom-dwelling or reef-inhabiting fish.

[1969](#) ✓

Kury, C. R. 1969. **Pesticide residues in a marine population of double-crested cormorants.** J. Wildl. Manage. 33: 91-95.

"Cunner (Tautogolabrus adspersus), rock eel (Pholis gunnellus), and American eel (Anguilla rostrata) were the major food items of cormorants [at colonies in Muscongus Bay, Maine] in 1966 and 1967 (observations with no collections for the latter year). Sculpin (Myoxocephalus sp.) and flatfish (Pleuronectiformes) were also noted."

Vermeer, K. 1969. **Some aspects of the breeding chronology of double-crested cormorants at Lake Newell, Alberta, in 1968.** Murrelet 50: 19-20.

The diet at Lake Newell in 1968 "was chiefly composed of northern pike (Esox lucius) and common whitefish (Coregonus clupeaformis)."

[1971](#)

Bennett, G. W. 1971. **Management of Ponds and Lakes.** 2nd ed. Van Nostrand Reinhold Co., New York. 375 pp.

"Whenever and wherever numbers of fish-eating birds are concentrated, type C predation [Ricker's classification] probably is taking place. This type of predation commonly occurs around nesting colonies and during the migrations of such birds as herons, cormorants, mergansers, and pelicans. In type C situations the predators take all of the fish they are able to catch and swallow with limited regard to species taken; in so doing they may reduce excessive numbers of individual fishes comprising unusually successful year classes of one or several species. The predators commonly involved in type C situations are highly mobile and have great capacity for taking advantage of concentrations of prey species. Their activities result in thinning populations of fishes to a point where those escaping are able to find adequate food to make rapid growth and thereby attain large sizes. When the prey population reaches a certain minimum size, the law of diminishing returns makes it unprofitable for the predators to hunt further. The reproduction potential of warmwater fishes is geared to type C predation and many problems of fish management are a result of its loss [p161]."

To illustrate the potential impact of vertebrate predators on fish



populations in "the primitive environment," Bennett cites a flock of 1,000 cormorants that was observed feeding on Chautauqua Lake, Illinois, for a period of three weeks in the fall of 1954. Using a food-consumption estimate of 1.5 lb/day (assuming a maintenance diet of about 1 lb/day and capability of eating >2 lb/day), Bennett estimates that the cormorants consumed 1,500 lb of fish/day, or 15.75 tons during the three-week period. "Although these fish may have been mostly forage species, it is well to remember that if largemouth bass or crappies were more accessible the cormorants would have been eating bass or crappies as well [p162-163]."

"For a long time anglers looked upon fish predators as their direct competitors for the fishes of our streams and lakes and they destroyed . . . known fish eaters whenever the opportunity appeared. There is little doubt that some of these fish eaters, particularly fish-eating birds, may make serious inroads on abnormal concentrations of fish such as are found in hatchery ponds or in coldwater streams where numbers of hatchery-reared trout or salmon have been stocked. In most other waters their impact upon fish populations is likely beneficial [p163]."

"Man's own activities and attitudes regarding fishes are in part responsible for the poor fishing that has plagued him. This situation stems from his substitution of a new type of predation for that which occurs in nature. Man preys upon large fish, but protects and pampers small ones, which is just the opposite of what natural predators do. This new type of predation and protection, coupled with the fact that no change occurred in the fishes' breeding potential, results in excessive survival and competition among the young. In this competition bass and other game fish lose out to hoards of stunted crappies, sunfish, and yellow perch [p163]."

## [1972](#) ✓

DeLaRonde, G. G., II, and Y. A. Greichus. 1972. **Care and behavior of penned double-crested cormorants.** Auk 89: 644-650.

Forty-eight birds captured as nestlings in June 1969 and raised in cages at South Dakota State University were force-fed approximately 2,000 fathead minnows (*Pimephales promelas*) each day in four feedings/day for the first week. By the end of the week, all birds were taking four 8 inch bullheads (*Ictalurus melas*) daily unassisted.

## [1973](#)

Dunn, E. H. 1973. **Energy Allocation of Nestling Double-crested Cormorants.** Unpubl. Ph.D. dissertation, Univ. Michigan, Ann Arbor.



Ross, R. K. 1973. **A Comparison of the Feeding and Breeding Requirement of the Great Cormorant (*Phalacrocorax carbo* L.) and the Double-crested Cormorant (*P. auritus* L.) in Nova Scotia.** M.Sc . thesis, Dalhousie Univ., Halifax, Nova Scotia.

[1974](#) ✓

Oberholser, H. C. 1974. **The Bird Life of Texas.** E.B. Kincaid, Jr., ed. Univ. Texas Press: Austin, TX. 1069 pp.

"Prey fish, of little economic importance, include gunnel, sculpin, sandlance, capelin, herring, founder, a few eel; crustaceans, amphibians, aquatic insects, and plants are eaten miscellaneously [p91]."

Robertson, I. 1974. **The food of nestling double-crested and pelagic cormorants at Mandarte island, British Columbia, with notes on feeding ecology.** Condor 76: 346-348.

Analysis of food items regurgitated by chicks, 1969-1971, revealed a preponderance of species characteristic of the littoral-benthic zone, with commercially valuable fish comprising only a negligible proportion of the diet. Of 11 species recorded, five (penpoint gunnel, crescent gunnel, shiner seaperch, snake prickleback, and Pacific sandlance) occurred with a relative abundance of greater than 10% (in terms of individuals or weight).

[1975](#)

Dunn, E. H. 1975. **Caloric intake of nestling double-crested cormorants.** Auk 92: 553-565.

Examination of 28 regurgitants by adult birds at Duck Island, Isles of Shoals, New Hampshire, revealed the presence of at least seven fish species in the 17 samples in which remains were identifiable.

Kury, C. R., and M. Gochfeld. 1975. **Human interference and gull predation in cormorant colonies.** Biol. Conserv. 8: 23-34.

Fish regurgitated by adults and young at Duck Island, Isle of Shoals, Maine, 21 May-2 July 1970, were principally cunner (*Tautoglabrus adspersus*).

Wiens, J. A., and J. M. Scott. 1975. **Model estimation of energy flow in Oregon coastal seabird populations.** Condor 77: 439-452.

## 1976

Myers, G. L., and J. J. Peterka. 1976. **Survival and growth of rainbow trout (*Salmo gairdneri*) in four prairie lakes, North Dakota.** J. Fish. Res. Board Canada 33: 1192-1195.

In a study designed to evaluate the feasibility of raising trout commercially, four lakes in Stutsman County were stocked with fingerling (1.4-6.3 g) trout at a rate of about 500/ha in May 1971 or 1972. At the three lakes at which cormorants were observed feeding on trout, mortality in the first month after stocking averaged 68% (range 46-85%) versus 23% at the lake without cormorants. The excess mortality (about 45%) was attributed to predation by cormorants, although three other species of fish-eating birds (American white pelican, black-crowned night-heron, Franklin's gull) were observed at two of the lakes. Fall harvest rates at the two lakes that did not suffer summer kill were low (4.4 and 0.1% in two successive years at a lake with cormorants, and 0.8% at the lake without cormorants), and the ultimate impact of cormorants was unclear.

## 1977

Mitchell, R. M. 1977. **Breeding biology of the double-crested cormorant in Utah Lake.** Great Basin Nat. 37: 1-23.

Food items regurgitated by nestlings were examined at three colonies in 1973. Remains of black bullhead (*Ictalurus melas*), carp (*Cyprinus carpio*), and Utah chub (*Gila atraria*) were found at all three colonies, while goldfish (*Carassius auratus*) and white bass (*Roccus chrysops*) were found at one colony each. Fish ranged in size from 3 cm (goldfish) to 22 cm (bullhead).

Ross, R. K. 1977. **A comparison of the feeding and nesting requirements of the great cormorant (*Phalacrocorax carbo* L.) and the double-crested cormorant (*P. auritus* Lesson) in Nova Scotia.** Proc. Nova Scotia Inst. Sci. 27: 114-132.

## 1978

Burton, J. 1978. **L'alimentation estivale du fou de bassan, du grand cormoran et du cormoran aigrettes aux lacs de la Madeleine, en relation avec les pêches commerciales.** Unpubl. report prepared for the Fisheries and Marine Service of the Department of Environment (Canada) by the Centre de recherches écologiques de Montréal.

Furness, R. W. 1978. **Energy requirements of seabird communities: a bioenergetics model.** J. Anim. Ecol. 47: 39-53.

Holm, S. F., H. D. Irby, and J. M. Inglis. 1978. **First nesting record of double-crested cormorant in Texas since 1939.** Bull. Texas Ornithol. Soc. 11(2): 50-52.

[1979](#) ✓

Ainley, D. G., and G. A. Sanger. 1979. **Trophic Relations of Seabirds in the Northeastern Pacific Ocean and Bering Sea.** U.S. Fish and Wildlife Service, Wildl. Res. Report, 11: 95-122.

Provides no new information on diet, but summarizes "major," "minor," and "incidental" prey species based on published data from five localities (Bailey 1927, Munro and Clemens 1931, Palmer 1962, Robertson 1974) and provides a simplified summary of prey items at the Farallon Islands (subsequently published in detail by Ainley et al. 1981). Characterizes the double-crested cormorant as feeding primarily on midwater fish and secondarily on benthic fish and benthic crustaceans in inshore habitats.

Roney, K. 1979. **Preliminary results on the food consumed by nesting double-crested cormorants at Cypress Lake, Saskatchewan.** Proc. Colonial Waterbird Group Conf. 3: 257-258 (Abstract only).

Two hundred regurgitations from chicks were analyzed, 22 June-21 July. Preliminary analysis of the [200 chick regurgitation] samples identified 16 different food items. The two most important were the brook stickleback (Culaea inconstans) and white sucker (Catostomus commersoni), being present in 49% and 37% of the samples, respectively. The yellow perch (Perca flavescens), tiger salamander (Ambystoma tigrinum), and fathead minnow (Pimephales promelas) followed in importance."

"Few gamefish species were found in the samples. Only eight brook trout (Salvelinus fontinalis) were present. Preliminary observations indicate that the cormorants consumed few gamefish species and those taken were only done so as the opportunity presented itself."

Scanlon, P. F., L. A. Helfrich, and R. E. Stultz. 1979. **Extent and severity of avian predation at Federal fish hatcheries in the United States.** Proc. Ann. Conf. Southeast. Assoc. Fish Wildl. Agencies 32: 470-473.

Eighty managers of Federal fish hatcheries responded to a questionnaire in 1977. Only three (4%) indicated that double-crested cormorants were predators at their facilities; severity was judged to be "severe" at one hatchery, "significant" at one hatchery, and "slight" at one facility. Of 33 other species judged to be at least a "slight" problem, 15 (45%) were mentioned with a frequency equal to or greater than the double-crested cormorant.

## 1981

Ainley, D. G., , D. W. Anderson, and P. R. Kelley. 1981. **Feeding ecology of marine cormorants in southwestern North America.** Condor 83: 120-131.

In contrast to pelagic (*Phalacrocorax pelagicus*) and Brandt's (*P. penicillatus*) cormorants, double-crested cormorants fed primarily on schooling fish (66-67% versus 22-60%) that occurred at relatively shallow depths (22-33% occurred from the water surface to mid-depths versus 11-14%) over flat bottoms (63-67% versus 20-38%).

Knopf, F. L., and J. L. Kennedy. 1981. **Differential predation by two species of piscivorous birds.** Wilson Bull. 93: 554-556.

All fish regurgitated by double-crested cormorant chicks at Anaho Island, Pyramid Lake, Nevada, on 30 June 1976 were indigenous tui chubs (*Gila bicolor*). The 94 fish weighed an average of 113 g and averaged 172 mm (SD  $\pm$  14.3) in length. More than 50% of the fish were in the range of 151-180 mm. Of the five fish species in Pyramid Lake, the tui chub comprised 86% of all fish (by numbers) available to cormorants in water 0-15 m deep.

Pilon, C. 1981. **Alimentation et reproduction du grand cormoran (*Phalacrocorax carbo*) et du cormoran aigrettes (*P. auritus*) aux les de la Madeleine, Québec.** M.Sc. thesis, Univ. Montreal, Montreal, Quebec.

Salmon, T. P., and F. S. Conte. 1981. **Control of Bird Damage at Aquaculture Facilities.** U.S. Fish and Wildlife Service, Wildl. Manage. Leaflet 475, pp.

## 1982

Clapp, R. B., R. C. Banks, D. Morgan-Jacobs, and W. A. Hoffman. 1982. **Marine Birds of the Southeastern United States. Part I. Gaviiformes through Pelecaniformes.** U.S. Fish and Wildlife Service, FWS/OBS-82/01, 637 pp.

Clapp et al. do not provide any original observations, but provide a brief synthesis of the information found in Palmer (1962) and summarize other recent literature.

Henneman, W. W., III. 1982. **Environmental and Behavioral Influences on the Comparative Energetics of Anhingas, Double-crested Cormorants, and Flightless Cormorants.** Unpublished Ph.D. dissertation, Univ. Florida, Gainesville, Florida. ?pp.

O'Meara, T. E., W. R. Marion, O. B. Myers, and W. M. Hetrick. 1982. **Food habits of**

**three bird species on phosphate-mine settling ponds and natural wetlands.** Proc. Annual Conf. Southeast. Assoc. Fish Wildl. Agencies 36: 515-526.

Double-crested cormorants were collected on three settling ponds and three natural wetlands in north and central Florida, June-October 1981. Stomachs of birds collected on settling ponds contained remains of seven fish species (predominantly mosquitofish *Gambusia affinis*; shad, *Dorosoma* spp.; brown bullhead, *Ictalurus nebulosus*; and black crappie, *Pomoxis nigromaculatus*), while stomachs of birds collected on natural wetlands had remains of five fish species (predominantly shad, *Dorosoma* spp., and sunfish, *Lepomis* spp.). The "appreciable utilization of invertebrates by cormorants on settling ponds" reported by the authors may actually represent organisms ingested incidentally while feeding or may have been eaten by the fish.

### 1983

Hatch, J. J. 1983. **Diet of an expanding population of double-crested cormorant.** Colonial Waterbirds 6: 71 (Abstract only).

Food samples (200 regurgitations and many pellets) collected at Massachusetts coastal colonies in 1982 showed that the predominant prey continued to be non-schooling fish from rocky substrates.

Milton, G. R., and P. J. Austin-Smith. 1983. **Changes in the abundance and distribution of double-crested (*Phalacrocorax auritus*) and great (*P. carbo*) cormorants in Nova Scotia.** Colonial Waterbirds 6: 130-138.

Milton, R., and P. J. Austin-Smith. 1983. **Population Levels and the Relationships of Double-crested (*Phalacrocorax auritus*) and Great Cormorants (*P. carbo*) to the Sport and Inshore Commercial Fisheries of Nova Scotia, 1979-80.** Unpublished Admin. Report, Wildlife Conservation Division, Nova Scotia Dep. Lands and Forests, Kentville, Nova Scotia. 32 pp.

Matteson, S. W. 1983. **A Preliminary Review of Fishery Complaints Associated with Changes in Double-crested Cormorant Populations in Maine, Wisconsin, and the Great Lakes Region.** Report to Bureau of End. Resources, Wisconsin Dept. of Nat. Resources, Madison, WI.

Pilon, C., J. Burton, and R. McNeil. 1983. **Summer food of the great and double-crested cormorants on the Magdalen Islands, Quebec.** Canadian J. Zool. 61: 2733-2739.

Eighteen species of fishes were found in regurgitations, June-August 1977 and May-July 1978. Flatfishes (four species), cunner, and American sand lance were the predominant species in the diet in both years.

Weseloh, D. V., S. M. Teeple, and M. Gilbertson. 1983. **Double-crested cormorants of the Great lakes: egg laying parameters, reproductive failure, and contaminant residue in eggs, Lake Huron, 1972-1973.** Canadian J. Zool. 61: 427-436.

"The diet of the double-crested cormorant on the Great Lakes has not been studied. However, from observations we have made at various colonies (unpublished data), yellow perch (Perca flavescens) appears to be a major food item."

#### 1984

Craven, S. R., and E. Lev. 1984. **Ecology of the Double-crested Cormorant in the Apostle Islands with Special Emphasis on Food Habits and Depredations Abatement. Final Report.** Unpublished Admin. Report, Univ. Wisconsin, Madison, WI. 28 pp.

Hatch, J. J. 1984. **Rapid increase of double-crested cormorants nesting in southern New England.** Am. Birds 38: 984-988.

"Another factor [accounting for the rapid population increase] could be changes in food availability or diet. Most fish species eaten by cormorants are of no commercial interest, are rarely caught, and do not appear in the fisheries statistics, so that information on their availability is scanty and it is difficult to evaluate the indirect effects that commercial fishing may have had on cormorant prey. The results of a recent study of cormorant regurgitations in Massachusetts (Hatch, in prep.) when compared with earlier reports . . . suggest no dietary differences that could account for the population growth. The recent widespread increase in sand lance (Ammodytes) is reflected in the diet of cormorants at the Weepeekets but not Boston."

Ludwig, J. P. 1984. **Decline, resurgence, and population dynamics of Michigan and Great Lakes double-crested cormorants.** Jack-Pine Warbler 62:91-102.

Of 179 fish retrieved from a colony at Gravelly Island in Lake Michigan, Michigan, 1979-1981, 94% were alewives (*Alosa pseudoharengus*).

Schramm, H. L., Jr., B. French, and M. Ednoff. 1984. **Depredation of channel catfish by Florida double-crested cormorants.** Progr. Fish-Cult. 46: 41-43.

Within two weeks of stocking two ponds in Hendry County with 5-20 cm fingerling channel catfish in May 1979, 12 cormorants were feeding in the ponds and roosting on nearby poles. Consumption of catfish by cormorants was measured on 20 randomly selected days, 18 September-22 October, at a 2.5 hectare, 2.5 m deep, pond stocked with 75,000 3-8 cm fish in August 1980. Thirteen adult cormorants (mean number of birds recorded on the pond at hourly

intervals ranged from 1.6-3.1, with a maximum of five) consumed an estimated minimum of 246 catfish daily (19/bird). Mean number of catches/bird/hour ranged from 5.1-15.8. Most fish were estimated to be 7-16 cm in length. Assuming an average weight of 16 g, each cormorant consumed a minimum of 304 g of catfish daily. The birds continued to feed at the pond throughout the winter, and in spring 1981 they nested in a nearby cypress dome. By November 1981, approximately 50 cormorants were feeding in the pond.

#### 1985

Craven, S. R., and E. Lev. 1985. **Double-crested cormorant damage to a commercial fishery in the Apostle Islands, Wisconsin.** Proc. East. Wildl. Damage Control Workshop 2: 14-24.

Matteson, S. W. 1985. **Update on the population status of the double-crested cormorant (*Phalacrocorax auritus*) in Wisconsin.** Wisconsin Bureau of End. Resources, Report 17. Madison, WI. 7 pp.

#### 1986

Bayer, R. D. 1986. **Seabirds near an Oregon estuarine salmon hatchery in 1982 and during the 1983 El Nino.** NOAA (Natl. Oceanogr. Atmospheric Admin.) Fish. Bull. 84(2): 279-286.

Gallant, A. 1986. **Summer Food of the Double-crested Cormorant (*Phalacrocorax auritus* L.) on Prince Edward Island: a Preliminary Report.** Unpubl. Admin. Report, Fish Wildl. Div., Dep. Environ. Resources, Charlottetown, Prince Edward Island. 38 pp.  
Fifteen species of fish were identified in the stomachs of 90 cormorants containing recognizable prey collected on 29 freshwater ponds, May-August, with ninespine stickleback predominant in terms of individuals and gaspereau (alewife) and brook trout predominant in terms of weight. Brook trout represented only 4% of the individuals taken, but totaled 26% of the biomass; they were found in cormorants collected at seven (23%) of the 29 ponds, and at these sites it represented 16% of the individuals taken and 87% of the biomass. Ten species of fish were found in regurgitations at Ram Island, with threespine stickleback and banded killifish predominant in terms of individuals and cunner predominant in terms of weight. Five species of fish were found in regurgitations at Durell Point, with flounder predominating in terms of relative abundance (individuals and biomass).

Hirsch, K. 1986. **Colony expansion and food habits of double-crested cormorants**



**in Minnesota.** Pacific Seabird Group Bull. 13: 32-33 (Abstract only).

"Data indicate that cormorant populations are expanding in Minnesota [14,000 birds at 26 colonies] and that fish consumption is significant."

"Analysis of chick regurgitations revealed that game fish (perch, walleye, and crappie) comprised up to 82% of the samples. Fish lengths averaged 5.82 cm at the Chataqua Lake site, and 6.54 cm at the Lake of the Woods site. Fish weights averaged 91.67 g at Chataqua and 117.12 g at lake of the Woods. Frequency of occurrence and relative frequency of occurrence were also calculated."

Price, I. M., and D. V. Weseloh. 1986. **Increased numbers and productivity of double-crested cormorants, Phalacrocorax auritus, on Lake Ontario.** Canadian Field-Nat. 100: 474-482.

"A second factor [in the recently increased productivity of cormorants on Lake Ontario] is the appearance of alewives (Alosa pseudoharengus) and rainbow smelt (Osmerus mordax) in the 1870s and 1930s, respectively, in Lake Ontario (Scott and Crossman 1973). Both species are abundant and available to the cormorants. We believe that first persecution and then contamination outweighed the positive effects of abundant food and that nest site availability has not been a limiting factor."

## 1987

Birt, V. L., T. P. Birt, D. Goulet, D. K. Cairns, and W. A. Montevecchi. 1987.

**Ashmole's halo: direct evidence for prey depletion by a seabird.** Mar. Ecol. Prog. Ser. 40: 205-208.

"An analysis of stomach contents of Ram Island [Prince Edward Island double-crested] cormorants in 1985 revealed mostly cunners, flounders (winter flounder Pseudopleuronectes americanus and American plaice Hippoglossoides platessoides) and grubbies Myoxocephalus aenus (35.5%, 18.1% and 11.9% respectively by mass, Gallant 1986)."

In July 1985, densities of fish species preyed on by double-crested cormorants were determined in four bays on Prince Edward Island located various distances from two large cormorant colonies. All bays were similar except for the presence or absence of foraging cormorants. Fish densities were significantly (83%) lower in two bays used by cormorants for feeding than in two bays outside their foraging range (i.e., 3.6 versus 21.0 fish/transect). These findings provide direct evidence of prey depletion.

"It should be emphasized that cormorants have not been found to feed extensively on commercially important fish species (such as salmon and trout), and that there is no commercial finfish fishery in the bays used by Ram Island cormorants."



"Seabird populations that are limited by food [versus human factors such as disturbance, as is now apparently the case with cormorants] may be vulnerable to competition with commercial fisheries."

Butler, J. 1987. **Cormorants: winter's winged villains.** Honey Hole: The Trophy Bass Mag. Texas 3(5): 32-33.

Craven, S. R., and E. Lev. 1987. **Double-crested cormorants in the Apostle Islands, Wisconsin, USA: population trends, food habits, and fishery depredations.** Colonial Waterbirds 10: 64-71.

In 1984, 13 fish species were reported in regurgitation and pellet samples collected from Egg and Gull islands, with small forage fishes such as sticklebacks, sculpins, and burbot predominating in the diet. Lake whitefish and lake trout, the two important commercial species of the area, were each found in only 1% of the samples. The cormorants "generally ate fish 12-15 cm long; however, several stomach regurgitations containing fish 35 cm long were collected from Gull Island."

Cummings, M. V. 1987. **The feeding energetics of the double-crested cormorant in Biscayne Bay, Florida.** Ph.D. dissertation, Univ. Miami, Coral Gables, Florida. 161 pp.

Dukes, C. 1987. **Portrait of a predator: are cormorants hurting Texas fishing?** Texas Fisherman 38 (June): 40-41.

"A director at the [Texas Parks and Wildlife Department's]... fish hatchery near San Angelo reported in April 1985 that up to 5,000 rainbow trout were lost to [double-crested cormorants], along with an unverifiable number of forage fish."

"In the same report, a hatchery manager reported moderate predation by cormorants against smallmouth bass brood stock and forage fish production ponds near Fort Worth." At the "Jasper hatchery, 13,000 rainbow trout were lost, as was 90 percent of the hatchery's two-year-old Florida bass brood stock."

Haws, K. 1987. **Colony expansion and food habits of double-crested cormorants.** Unpubl. Admin. Rep., Minnesota Dept. Natl. Resources. 6 pp.

Analysis of regurgitations at two colonies in Minnesota in 1985 indicated that yellow perch predominated in the diet at a colony in Lake of the Woods County, while brook stickleback and unidentified minnows (*Notropis* spp.) predominated at Chataqua Lake, Otter Tail County.

Kehoe, F. P. 1987. **The effect of double-crested cormorant predation on the salmon genetics research program (SGRP).** Salmon Genetics Research Project Tech. Rep. 66. Atlantic Salmon Federation, St. Andrews, New Brunswick.

Kehoe, F.P. 1987. **The effect of double-crested cormorant predation on the salmon genetics program.** Salmon Genetics Research Program Tech, Rep. 66.

Kennedy, G. J. A. 1987. **Predation by cormorants (*Phalacrocorax carbo* L.) on wild and hatchery salmon smolts (*Salmo salar* L.).** Int. Counc. Expl. of the Sea. North Atlantic Salmon Working Group. 8 pp.

Nettleship, D. N. 1987. **Cormorants: scapegoats or fish-hogs?** Pacific Seabird Group Bull. 14: 35 (Abstract only).

"Investigations of the food of double-crested . . . and great . . . cormorants in Atlantic Canada, conducted between 1914 and 1985, have not conformed this [impression that the birds consume vast quantities of valuable fish] Instead, these studies indicate that breeding birds feed almost entirely on fish of no economic importance, with immatures and non-breeders sometimes exerting a small local pressure on salmonids associated with inland water systems. Overfishing by man remains the factor most likely responsible for depletion of some commercial fish stocks in coastal marine waters."

Parkhurst, J. A., R. P. Brooks, and D. E. Arnold. 1987. **A survey of wildlife depredation and control techniques at fish-rearing facilities.** Wildl. Soc. Bull. 15: 386-394.

175 managers of fish hatcheries (19 State, 66 Federal, 36 commercial, and 54 cooperative), predominantly in the eastern U.S., responded to a survey questionnaire in 1984. Only eight (5%) of the managers (all Federal) reported that cormorants were predators at their facilities. Of 91 other (including non-avian) species mentioned as predators, 46 (50%) were listed more frequently than cormorants.

Schramm, H. L., Jr., M. W. Collopy, and E. A. Okrah. 1987. **Potential problems of bird predation for fish culture in Florida.** Progr. Fish-Cult. 49: 44-49.

Assuming that cormorants have a mean body weight of 1,800 g, and that prey fish have a mean caloric content of 1.5 kcal/g fresh weight, authors calculate food-consumption rates of 213 g/day in summer and 247 g/day in winter in north Florida, and 208 g/day in summer and 230 g/day in winter in south Florida. Among 35 species of fish-eating birds examined, only five (American white pelican, brown pelican, great blue heron, wood stork, bald eagle) had higher food-consumption rates.

## 1988

Campo, J. J., B. Thompson, J. C. Barron, P. P. Durocher, and S. J. Gutreuter. 1988. **Feeding Habits of Double-crested Cormorants Wintering in Texas.** Texas Parks

Wildl. Dep. Final Rep., Fed. Aid Proj. W-103-R. 32 pp.

Carroll, J. R. 1988a. **Population Growth of the Double-crested Cormorant (*Phalacrocorax auritus*) and its Potential for Affecting Sport Fisheries in Eastern Lake Ontario.** New York Dep. Environ. Conserv., Div. Fish Wildl., Nongame Unit, Delmar, New York. 10 pp.

"Cursory observations of dead fish found in the nesting area at Little Galloo [Island, Lake Ontario] during 1986 and 1987 were of alewives . . . No significant impact on alewife numbers or age composition because of increased predation on alewives by cormorants and the increasing number of salmonids in the lake has yet been documented (Christie et al., in press)." "Because of the proximity of cormorant colonies in east Lake Ontario to salmonid stocking sites, it is possible that some cormorants do exploit fingerling and yearling salmonids as food. The cormorant is an opportunistic feeder and would take advantage of unwary young fish. It is, however, unlikely that these are the main diet of cormorants in eastern Lake Ontario. Fisheries biologists do not believe that the cormorants are having a major impact on stocked fish (Letendre, pers. comm.) and they, along with wildlife biologists, believe that the diet of the cormorant is mainly of the abundant alewife."

Carroll, J. R. 1988b. **The cormorants of Little Galloo.** Conservationist 42(6): 37-39.

"The presence of cormorants in areas of sport fisheries is and always has been controversial. Despite the fact that studies conducted in such states and provinces as Maine, Wisconsin, Manitoba, and Nova Scotia indicated that commercial and sport fish make up only a very small fraction of fish in the diet of the cormorant, convincing fishermen is sometimes a difficult task. This is particularly true when cormorants are observed in areas where hatchery reared fish are released, as they are in Lake Ontario. Every year thousands of fingerling and yearling salmon and trout are released in the bays within range of the cormorant colony at Little Galloo Island. Cormorants are opportunistic and some undoubtedly do feed on the unwary fingerling or yearling salmonids, but most fisheries and wildlife biologists are convinced that the main prey of the cormorant in Lake Ontario is the abundant alewife. Current studies being conducted by the Canadian Wildlife Service on Little Galloo Island and at other Lake Ontario colonies should determine the diet of cormorants. If it is found that cormorants are having a definite negative impact on the stocked fish, measures can be taken, such as releasing the fish at night when the cormorants are not feeding, to reduce the impact. Predation of some stocked fish by cormorants, however, cannot be avoided."

[Cited in: Ewins and Weseloh 1994]

[Qualitative: impacts]

Claypoole, K. 1988. **First nesting of the double-crested cormorant at Oneida**

**Lake, New York.** Kingbird 38: 235-236.

"Richard Colesante of the New York State Department of Environmental Conservation (pers. comm.) visited Wantry Island during the summer of 1987 [when it contained 18 active cormorant nests] and reported observing only gizzard shad in the food material regurgitated by the cormorant chicks."

Farmer, G. J., D. Ashfield, and D. K. MacPhail. 1988. **Predation of juvenile Atlantic salmon by the double-crested cormorant.** Unpublished manuscript.

Findholt, S. L. 1988. **Status, distribution, and habitat affinities of double-crested cormorant nesting colonies in Wyoming.** Colonial Waterbirds 11: 245-251.

"Although quantitative data are lacking on the diet of cormorants in Wyoming, it appears that yellow perch (Perca flavescens), carp (Cyprinus carpio), suckers (Catostomus spp.) and other 'undesirable' fishes are major prey species (Findholt unpubl. data). Many of these fish species were introduced into the state and are prevalent in the reservoirs (Baxter and Simon 1970)."

Gallant, E. A. 1988. **Summer food habits and feeding behaviour of the double-crested cormorant Phalacrocorax auritus on Prince Edward Island.** M.Sc. thesis, Acadia Univ., Wolfville, Nova Scotia. 91 pp.

Milton, G. R., P. J. Austin-Smith, and G. E. Dickie. 1988. **An Examination of the Diet of Double-crested Cormorants (Phalacrocorax auritus) Foraging in Coastal and Inland Waters.** Unpublished Admin. Report, Wildl. Div., Dep. Lands and Forests, Kentville, Nova Scotia. 32 pp.

Montevecchi, W. A., D. K. Cairns, and V. L. Birt. 1988. **Migration of postmolt Atlantic salmon, Salmo salar, off northeastern Newfoundland, as inferred by tag recoveries in a seabird colony.** Canadian J. Fish. Aquat. Sci. 45: 568-571.

The authors report that salmon comprised < 1% of 2,928 regurgitated food samples collected from gannets at Funk Island, and note that "Salmon tags have also been recovered from [unspecified species of] cormorants . . . although these data are yet to be published. . . Preliminary plans are also being made to use metal detectors to search for metallic salmon tags in cormorant colonies in British Columbia."

## 1989

Bayer, R. D. 1989. **The cormorant/fisherman conflict in Tillamook County, Oregon.** Stud. Oregon Ornithol. 6, 99 pp.

Birt-Friesen, V. L., W. A. Montevecchi, D. K. Cairns, and S. A. Mackes. 1989.

**Activity-specific metabolic rates of free-living northern gannets and other seabirds.** Ecology 70: 357-367.

Bivings, A. E. M. D. Hoy, and J. W. Jones. 1989. **Fall Food Habits of Double-crested Cormorants in Arkansas.** Pgs. 142-143 in Ninth Great Plains Wildlife Damage Control Workshop Proceedings. USDA Forest Service Gen. Tech. Rep. RM-171.

Hobson, K. A., R. W. Knapton, and W. Lysack. 1989. **Population, diet, and reproductive success of double-crested cormorants breeding on Lake Winnipegosis, Manitoba, in 1987.** Colonial Waterbirds 12: 191-197.

Diet was assessed by collecting 6,169 food items regurgitated by cormorants at 37 colonies on 497,017-ha Lake Winnipegosis, west-central Manitoba, May-September 1987. "We collected 6,169 prey samples representing 16 fish and one crayfish species. Yellow perch (*Perca flavescens*) were the most frequent but white sucker (*Catostomus commersoni*) made up nearly half the prey biomass. The commercially valuable species, walleye and sauger, accounted for a maximum of only 0.1 and 0.2% of the prey biomass, respectively. The mean length of perch taken in June, during the late incubation to early chick period, was  $98.6 \pm 37.9$  mm (SD;  $n = 427$ ). This increased to  $121.3 \pm 31.4$  mm ( $n = 1,820$ ) in July (Wilcoxon 2-sample test:  $Z = 11.95$ ,  $p < 0.0001$ ) during the nestling period. In August, when regurgitations reflected primarily adult or fledged chick diet, mean length of perch decreased again to  $98.7 \pm 37.3$  mm ( $n = 487$ ;  $Z = 12.02$ ,  $p < 0.0001$ )."

This study provides additional support to the contention that, despite recent population increases, double-crested cormorants seldom take commercially valuable fish (see also Lewis 1929, Mendall 1936, Scattergood 1950, Behle 1958, Robertson 1974, Roney 1979, Knopf and Kennedy 1981, Craven and Lev 1987, Draulans 1988). The commercially valuable species, walleye and sauger, did not contribute significantly to the diet of double-crested cormorants breeding on Lake Winnipegosis in 1987. Cormorants fed on a wide range of prey. The three most important prey species, suckers, perch, and tullibee, concentrate in large schools and thus may be most vulnerable to cormorants. We observed several large feeding flocks in the course of our study and, when sampling prey at these locations, found only these species. Fishermen informed us that whenever they set nets in areas where cormorant flocks occurred, they typically caught only large numbers of suckers. Larger predatory fish such as walleye, sauger, and pike, as well as being less abundant in Lake Winnipegosis, are solitary or occur in loose aggregations when not spawning (Lysack 1988). These species may thus be encountered less frequently by cormorants."

Ludwig, J. P., C. N. Hull, M. E. Ludwig, and H. J. Auman. 1989. **Food habits and**

**feeding ecology of nesting double-crested cormorants in the Upper Great lakes, 1986-1989.** Jack-Pine Warbler 67: 117-129.

Ludwig, M. E., and J. P. Ludwig. 1989. **Food habits of double-crested cormorants in lakes Huron, Michigan, and Superior: implications for toxic chemical contaminant transfer from fish to cormorants.** Int. Assoc. Great Lakes Conf. 32: 75 (Abstract only).

Stickley, A. R., Jr., and K. J. Andrews. 1989. **Survey of Mississippi catfish farmers on means, effort, and costs to repel fish-eating birds from ponds.** Proc. East. Wildl. Damage Control Conf. 4: 105-108.

Of 281 farmers queried on the Delta, 87% felt that they had a bird problem. Moderate-heavy cormorant activity (defined as at least 25 birds/day) was reported by 57% of Delta farmers. Losses to birds (harassment costs plus value of fish lost) was estimated at \$5.4 million (3% of total sales) in 1988.

#### 1990

Glahn, J. F., and P. Dixon. 1990. **Cormorant diet and its impact at Mississippi catfish farms.** For Fish Farmers Newsletter, Mississippi Cooperative Extension Service. September 10, 1990, 90: 2

Erickson, K. E. 1990. **Summary of Survey Responses: Cormorant Predation on State Sportfish Populations.** Unpublished Report prepared by Oklahoma Dep. Wildl. Conserv. for Am. Fish. Soc. 5 pp.

A questionnaire was sent to the fisheries chief of each State on 18 July 1990, and responses were received from 39 States in which double-crested cormorants occur with regularity. Anglers were reported to have expressed increasing concern about cormorant predation on sportfish populations in 31% of the States, 23% of the State fisheries chiefs were concerned about cormorant predation on sportfish or forage fish populations, the public was thought to be somewhat or extremely concerned about cormorant predation in 38% of the States, and 33% of the States reported an increase in cormorant predation in hatchery ponds and raceways.

Stickley, A. R., Jr. 1990. **Cormorant feeding rates on commercially grown catfish.** Mississippi Coop. Ext. Serv. Ref. 90-4: 4-6.

#### 1991

Cairns, D. K., G. Chapdelaine, and W. A. Montevecchi. 1991. **Prey exploitation by**

**seabirds in the Gulf of St. Lawrence.** Pp. 277-291 in J.C. Therriault, ed., The gulf of St. Lawrence: small ocean or big estuary? Canadian Spec. Publ. Fish. Aquat. Sci. 113.

Conniff, R. 1991. **Why catfish farmers want to throttle the crow of the sea.** Smithsonian 22(4): 44-50, 52, and 54-55.

"On any winter evening, 35,000 cormorants now return to roosts around the Delta. Traveling with them, in cargo, are perhaps 20,000 pounds of catfish, which might be worth \$16,000 if they were not already in advanced stages of digestion. . . Federal researchers last year examined the stomach contents of 136 cormorants in the fish farms of the Mississippi Delta and found that 64 percent of their diet consisted of catfish. The fish farmers themselves estimated their direct losses at \$3 million a year, plus \$2.1 million for butane cannon and the like. . . Losses from other factors can be at least as bad. Indeed, according to the Department of Agriculture's own statistics, 70 percent of catfish losses nationally are due to disease and another 10 percent to oxygen depletion; birds account for only 7 percent of the total."

Post, W., and C. A. Seals. 1991. **Breeding biology of a newly-established double-crested cormorant population in South Carolina, USA.** Colonial Waterbirds 14: 34-38.

"We collected 11 regurgitant samples from young cormorants [at two colonies on Lake Moultrie] during the period 28 June-21 August 1989. The only species contained in the samples was thread herring (*Dorosoma cepedianum*) (mean standard length = 66.4 mm, n = 51)."

Stickley, A. R. 1991. **Cormorant feeding rates on commercially grown catfish.** Aquacult. Mag. 17(March-April): 89-90.

Feeding rates (catfish consumed/cormorant-hour) ranged from "near zero" to 22.9, with an average of 4.75 (SD = 6.95); the average does not include two complexes where birds were rafted up and resting, and one complex where a severe sick fish situation existed. The average catfish consumed by cormorants was about 5.5 inches in length, which "agrees with the results of cormorant food habits collections, which indicated that 76% of the catfish taken ranged from 4 to 8 [inches] in length."

"A high number of cormorants on a pond often means a lower feeding rate. When cormorants are rafted up, they tend not to feed as much as when they are scattered out individually over the pond. The presence of even a few cormorants on a catfish facility, particularly if there is a fairly continuous turnover in individuals in the vicinity of fingerling ponds, represents a serious depredation threat that should be met with aggressive efforts to reduce losses."

[1992](#)

Brugger, K. E. 1992a. **Double-crested cormorants and fisheries in Florida.** Colonial Waterbird Soc. Bull. 16(2): 49 (Abstract only).

"Overall, little conflict occurs between cormorants and the food- or game-fish industries in Florida. Specific conflicts exist when wintering cormorants feed at inland hatcheries, grow-out ponds, and ornamental-fish ponds, where high-value crops may be completely lost to fish-eating birds."

Brugger, K. E. 1992b. **Differential digestion of fish by double-crested cormorants (*Phalacrocorax auritus*).** Colonial Waterbird Soc. Bull. 16(2): 62 (Abstract only).

Ad libitum food intake ranged from 264-503 g/bird/day, resulting in apparent metabolizable energy of 616-1,282 kJ/kg/day. Estimated metabolizable energy coefficients (MECs) ranged from 77.9-89%, with values for catfish and gizzard shad being higher than those for bluegills. Nitrogen corrections reduced MECs to 74.7-79.7%.

Brugger, K. E. 1992c. **Differential digestibilities of channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), and gizzard shad (*Dorosoma cepedianum*): in vitro standards.** Colonial Waterbirds 15: 257-260.

"If the in vitro estimates for fish digestibilities correctly predict the relative in vivo responses of birds, then these data suggest that a fish-eating bird would digest gizzard shad and channel catfish faster than bluegill (24 hrs vs >34 hrs) in these size classes. If true, the ranking of fish digestion rates suggests a digestive component of food selection. Assuming all other factors (such as foraging effort) are equal, fish-eating birds such as double-crested cormorants may select the most easily processed fish of those available, i.e., the species or size class that digests the most rapidly. . . These digestibility data may be used to... correct estimates of food habits of individuals in field studies where gut contents are sampled..."

Cairns, D. K. 1992. **Bridging the gap between ornithology and fisheries science: use of seabird data in stock assessment models.** Condor 94: 811-824.

"Yield-per-recruit analyses, derived from fisheries science, suggest that under plausible conditions the impact of seabird predation on fish stocks may be amplified by avian preference for small prey. . . The impact of bird predation depends crucially on avian prey size selection and the growth and mortality schedules of the fish populations," as illustrated by bioenergetics models simulating biomass changes of winter flounder (*Pseudopleuronectes americanus*), a significant prey of double-crested cormorants in the Gulf of St. Lawrence. With non-avian juvenile mortality set low (equivalent to 26% annual death rate), peak biomass of flounders is reduced 91% by cormorant predation when they target age-2 fish (i.e., "the birds remove so many small fish that few ever reach commercial size") but only 13% when they target age-5 fish (i.e.,



"bird impact on the stock is much less because cohort biomass has already grown substantially before avian harvest"). With non-avian juvenile mortality set high (equivalent to 63% annual death rate), peak biomass is reduced 45% when cormorants target age-2 fish and 13% when they target age-5 fish (i.e., "impact on the stock is reduced under this assumption because most of the small fish taken by birds would have succumbed to natural mortality in the absence of avian predation").

Custer, T. W., and C. Bunk. 1992. **Feeding flights of breeding double-crested cormorants at two Wisconsin colonies.** J. Field Ornithol. 63: 203-211.

Birds from two colonies in Lake Michigan foraged an average of 2.0-2.4 km from the colonies, with > 90% of flights being to localities within 9 km of the colonies. More than 80% of the birds foraged in waters 9 m in depth.

Glahn, J. F., and K. E. Brugger. 1992. **The impact of double-crested cormorants on the Mississippi delta catfish industry: a bioenergetics model.** Colonial Waterbird Soc. Bull. 16(2): 63 (Abstract only).

"Predictions from this [bioenergetics] model for the winters of 1989-90 and 1990-1 indicated the greatest losses occurring during March of each year to recently stocked catfish fingerlings."

Glahn, J. F., and A. R. Stickley Jr. 1992. **Wintering double-crested cormorants in the delta region of Mississippi: population levels, diet, and their impact on the catfish industry.** Colonial Waterbird Soc. Bull. 16(2): 49 (Abstract only).

Populations and diets were similar during the winters of 1989-90 and 1990-1 (Nov-Apr), "with peak populations of about 30,000 birds occurring in March and April and the diet comprising approximately 50% catfish... the impact of cormorants on the catfish industry was predicted to involve removing approximately 4% of the catfish fingerlings at a cost of \$2 million annually."

Glanville, E. V. 1992. **Co-operative fishing by double-crested cormorants, Phalacrocorax auritus.** Canadian Field-Nat. 106: 522-523.

Describes organized behavior, observed along the North shore of Georgian Bay, in which 50-175 birds may cooperate to drive fish into a confined area: "I have repeatedly observed flocks of cormorants assemble at the mouth of such bays [long parallel-sided inlets from 50-150 m across and > 200 m in length] as dawn breaks... These cormorants then spread out across the inlet, forming a narrow ribbon or arc from shore to shore. They then proceed up the inlet in a commotion of splashing wings, dipping and diving, in a line of astonishing regularity, to the head of the bay where a frenzy of feeding takes place... cormorants have suffered persecution in this area and are extremely wary of humans. I have only observed such co-operative behavior in less frequented bays when no boats are about and then only in the early morning. As far as I

have been able to determine, co-operative fishing is confined to the late summer and early fall when large numbers of adults and juveniles congregate together." Speculates that, "If ...cooperative fishing in bays increases significantly in the later part of the year, as my data suggest, then this may result in a greater proportion of in-shore fish such as perch being taken [than has been documented on the basis of analyses of regurgitations collected at breeding colonies] and casts doubt on the legitimacy of extrapolating information gathered at nesting sites to other times of year."

Hatch, J. J. 1992. **Cormorant and clam.** Bird Observer (Massachusetts) 20: 156-157.

On 19 May 1985 at Middle Weepecket Island, Massachusetts, an adult double-crested cormorant was observed with a hard-shelled clam around the tip of its lower mandible. "Cormorants usually feed only on fish, and this bird may have encountered the clam while seeking demersal prey, such as a rock eel (gunnel) or sand lance, which comprise a large part of the diet in this area."

King, D. T., J. F. Glahn, and K. J. Andrews. 1992. **Daily activity budgets and movements of winter-roosting double-crested cormorants in the delta region of Mississippi using biotelemetry.** Colonial Waterbird Soc. Bull. 16(2): 52-53 (Abstract only).

"Cormorants flew an average of 15.7 km from their night-roost to a foraging location during the winters of 1990-91 and 1991-92. During the winter of 1991-92 foraging averaged 7.9% of cormorant daily activity."

Koontz, W. H. 1992. **Double-crested cormorant populations and food habits on Lake Winnipegosis, Manitoba.** Abstract only in Symposium on aquatic birds in the trophic web of lakes. Canadian Wildlife Serv., Sackville, New Brunswick.

May, J. A. 1992. **An experimental "wire" grid for exclusion of double-crested cormorants from commercial catfish ponds.** For fish farmers (Mississippi Coop. Ext. Serv.) 92(1): 3.

Milton, R., P. J. Austin-Smith, and G. J. Farmer. 1992. **Shouting at shags: a case study of cormorant management in Nova Scotia.** Colonial Waterbird Soc. Bull. 16(2): 48 (Abstract only).

"[Double-crested cormorants] are more diverse in feeding habits and diet [than great cormorants], have a larger impact on commercial fisheries, and prey on wild and hatchery released salmonids... Losses of hatchery released salmon smolts were reduced by changing the time and location of release."

Mott, D. F., K. J. Andrews, and G. A. Littauer. 1992. **An evaluation of roost dispersal for reducing cormorant activity on catfish ponds.** Proc. East. Wildl.

Damage Control Conf. 5: 205-211.

Neuman, J. 1992. **Report on the Collection and Analysis of Adult Double-crested Cormorant Pellets for Eastern Lake Ontario, 1992.** Unpublished Admin. Report, Canadian Wildlife Serv., Burlington, Ontario. 42 pp.

Stickley, A. R., Jr. 1992. **Economics of cormorant depredations at Mississippi catfish farms.** Colonial Waterbird Soc. Bull. 16(2): 50-51 (Abstract only).

"Cormorants have been observed taking catfish fingerlings at rates as high as 28 per cormorant-hour. An average-sized flock of 30 cormorants (not necessarily the same individuals all the time) feeding 8 hours per day at an average rate of 5 fingerlings per cormorant-hour on only one 8-ha pond containing 51,000 fingerlings per ha would consume 1,200 fingerlings worth approximately \$84. This approximately equals the cost of one day of intensive harassment patrols on a 200-ha catfish farm. Cormorants feeding at the above rate and in the above numbers would consume half the fingerling population in this 8-ha pond in 167 days."

Stickley, A. R., Jr., G. L. Warrick, and J. F. Glahn. 1992. **Impact of double-crested cormorant depredations on channel catfish farms.** J. World Aquacult. Soc. 23: 192-198.

Based on observations at 14 catfish ponds in the Mississippi Delta, December 1989-April 1990, the authors report a mean consumption rate of five fish/cormorant-hour (range: 0-28), but the data are highly skewed; the median rate was only two fish/cormorant-hour, and the mean rate was equaled or exceeded at only three (21%) of the 14 ponds. The average number of cormorants counted on these same 14 ponds was 30 (range 2-122), but the median number was only 15. These figures are probably biased upwards, because the "Complexes [of catfish ponds included in this study were not a random sample of available complexes, but rather] were selected on the basis of growers' expectations of depredations and... within the complexes, ponds were identified that were most likely to receive cormorant use." For example, an additional five ponds were excluded from the calculations because they received no cormorant use (three ponds), cormorants were not observed feeding (one pond), or cormorants exhibited abnormal feeding behavior because of a severe fish die-off (one pond). Inclusion of these ponds in the sample would have reduced the mean consumption rate.

Assuming averages of five fingerling catfish consumed/cormorant-hour and 30 cormorants/pond (a constant number of feeding birds present throughout an eight hour day), authors conclude that the catfish population of a typical pond (51,000 fish/ha in an eight hectare pond) would be halved in 167 days [Note: the statement in the abstract that the fish population would be halved in 30 days implies a maximum consumption rate of 28 fish/cormorant-hr]. However, if actual

values were nearer the median values of two fish/cormorant-hr and 15 birds/pond, the number of days required for the cormorants to reduce the population by half would be increased to 850 days (a fivefold increase)! This paper illustrates some of the pitfalls in trying to apply field data to estimate impacts.

There was no significant correlation between the mean number of cormorants present and the number of catfish consumed/cormorant-hour (but ponds with 40 cormorants generally had a consumption rate of one catfish/cormorant-hour). Similarly, the number of catfish consumed/cormorant-hour was not significantly correlated with density of fingerling catfish, density of all catfish (all size classes combined), or mean length of fish.

"An average of 30.5 cormorants feeding for an hour at the average consumption rate would cost \$13.45 [or about \$0.09/fish at 1990 prices] . . . The average estimated length of 269 catfish observed being consumed by cormorants was 12 cm (SE = 0.08, range = 5.0-30.5). This mean estimated length is only slightly less than the mean length (15 cm, SE = 2.70) of catfish found in cormorant stomachs from the same area in Mississippi (unpublished data, May 1991)." The 10-15 cm fingerlings that were apparently preferred by the cormorants represented about 64% of the catfish (by number) in the ponds. One of the 14 ponds contained gizzard shad (*Dorosoma cepedianum*) in addition to catfish. The consumption rate was 19.2 shad versus only 0.14 catfish/cormorant-hour. The apparent preference for gizzard shad may be related to their being more easily handled and swallowed by cormorants (mean handling time for catfish was 6-7 times greater than that of gizzard shad).

Weseloh, D. V., and J. Casselman. 1992. **Calculated Fish Consumption by Double-crested Cormorants in Eastern Lake Ontario, 1992.** Unpublished Admin. Report, Canadian Wildlife Service, Burlington, Ontario. 42 pp.

Weseloh, D. V., and J. Casselman. 1992. **Calculated fish consumption by double-crested cormorants in eastern Lake Ontario.** Colonial Waterbird Soc. Bull. 16(2): 63-64 (Abstract only).

"If [Double-crested cormorants] consume 0.47 kg fish/day (25% of their 1.9 kg body wt.), then they ate 1.8 million kg in 1991 [assuming 28,000 adult, immature, and juvenile DCCs and 3.84 million DCC feeding days] Local studies show alewife, yellow perch, and other, mainly warmwater, species to be the main fish species consumed. Alternately, using size estimates of the lake trout population and relative numbers of warmwater predators, growth rates, and conversion efficiencies, we estimate that the 28,000 [cormorants] in eastern Lake Ontario have a predatory effect equal to approximately five times that many lake trout, or less than 5% of the predatory fish population. Overall, this level of predation is not considered significant competition to the cold or warmwater fish community."

Weseloh, D. V., P. J. Ewins, and J. Neuman. 1992. **Double-crested cormorants of the Great Lakes: population changes, diet, fisheries conflicts, and band recovery.** Colonial Waterbird Soc. Bull. 16(2): 47-48 (Abstract only).

"The present diet of Great Lakes [double-crested cormorants] is primarily alewife and yellow perch; small numbers of smelt, pike, pickerel, and centrarchids are taken. Fishermen complain that [cormorants] are scaring fish caught in commercial nets, taking sport fish during stocking, and eating and/or competing with major sport fish for food."

### 1993

Brugger, K. E. 1993. **Digestibility of three fish species by double-crested cormorants.** Condor 95: 25-32.

"Ad libitum intake [of captive cormorants] ranged from 264 to 503 g/bird<sup>-1</sup>/day<sup>-1</sup> among tests, resulting in metabolizable energy values of 616 to 1,334 kJ/kg<sup>-1</sup>/day<sup>-1</sup>." "Assuming an average daily energy demand of 1,380 kJ/bird<sup>-1</sup>/day<sup>-1</sup> (with no variation due to sex, age, or season), a hypothetical diet composed of 50% catfish, 25% shad, and 25% sunfish . . . and the fish energy contents and MEC<sub>N</sub> obtained above (78-89% and 75-79%, respectively), then an average double-crested cormorant should eat 320 g fish/day<sup>-1</sup>, 160 g of which would be catfish. Cormorants in the Mississippi delta tend to specialize on 10-20 cm fingerlings (Glahn and Dixon 1990), which may weigh 15-80 g. Current replacement cost is about \$0.20 per fingerling. Thus, in this scenario, a single cormorant would take 2-11 catfish per day at a cost of \$0.40 to \$2.20/bird<sup>-1</sup>/day<sup>-1</sup>. Little information is available to quantify standing crop or fish losses due to cultural practices (aeration, water temperature, disease), thus the proportional losses of catfish to fish-eating birds relative to background losses currently cannot be determined."

Campo, J. J., B. C. Thompson, J. C. Barron, R. C. Telfair II, P. Durocher, and S. Gutreuter. 1993. **Diet of double-crested cormorants wintering in Texas.** J. Field Ornithol. 64: 135-144.

Haeghele, C. W. 1993. **Seabird predation of Pacific herring, *Clupea pallasii*, spawn in British Columbia.** Canadian Field-Nat. 107: 73-82.

Cormorants of three species (including double-crested) noted in association with herring spawning areas in the Strait of Georgia (1989-1990) were most abundant when there was active spawning (with a peak of 2,080 cormorants in 1990 representing about 4% of the total seabirds present), but were not observed feeding on herring spawn.

Jones, M. L., J. F. Koonce, and R. O'Gorman. 1993. **Sustainability of hatchery**

**dependent salmonine fisheries in Lake Ontario: the conflict between predator demand and prey supply.** Trans. Am. Fish. Soc. 122: 1002-1018.

[1994](#)

Blackwell, B. F., and W. B. Krohn. 1994. **Foods of nestling double-crested cormorants in Penobscot Bay, Maine: spatial and temporal comparisons.** Colonial Waterbird Soc. Bull. 18(2): 37-38 (Abstract only).

"Consistent with Mendall's (1936) findings, nestlings were fed primarily benthic species of no commercial value. Importantly, we recovered otoliths of commercially important benthic species from the remains of fish fed to nestlings. Given concerns regarding the decline of commercially important benthic species in the Gulf of Maine, we suggest double-crested cormorant predation serves a potentially beneficial role as a predator of fish species which consume the eggs and juveniles of commercial, benthic species."

Ewins, P. J. 1994. **Editorial. Aquatic birds in recovering ecosystems-management conflicts.** J. Great Lakes Res. 20: 597-598.

"Many studies worldwide have examined cormorant diets and virtually all have reached the same conclusion, that cormorants eat mainly fish species (usually those up to about 25 cm long) which are not exploited heavily by commercial or sport fisheries. A study by Linn and Campbell (1993) found that in Lake Malawi cormorants consumed 3.8% of the fish harvest taken by the human fishery. A similar figure has been calculated for Lake Ontario. Clearly, despite such studies cormorants are still perceived by some fish harvesters as undesirable competitors, even though the evidence points to factors such as over-fishing, introduction of exotic species, and changes to nutrient and energy dynamics in lakes as having the greatest impact on fish stocks."

Ewins, P. J., and D. V. Weseloh. 1994. **Effects on productivity of shooting of double-crested cormorants (*Phalacrocorax auritus*) on Pigeon Island, Lake Ontario, in 1993.** J. Great Lakes Res. 20: 761-767.

"Recent studies in eastern Lake Ontario found that diets of adult and young cormorants were dominated by alewife (*Alosa pseudoharengus*), yellow perch (*Perca flavescens*), and various centrarchid species, including small-mouth bass (*Micropterus dolomieu*)..."

Karwowski, K. 1994. **Food Study of the Double-crested Cormorant, Little Galloo Island, Lake Ontario, New York, 1992.** Unpublished Admin. Report, U.S. Fish & Wildlife Serv., Cortland, New York. 22 pp.

Regurgitated pellets were collected about once a week, 4 April-16 July. Analysis of 938 pellets revealed presence of 24 fish species. Six species predominated

in the pellets: alewife (*Alosa pseudoharengus*), trout perch (*Percopsis omiscomaycus*), white perch (*Morone americana*), pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), and unidentified centrarchids (Table). Salmonids occurred in just 1% of the pellets, and no coded wire tags used to mark released lake trout (*Salvelinus namaycush*) were recovered.

MacNeil, D. 1994. **Feeding habits of cormorants in eastern Lake Ontario.** Unpublished Admin. Report, New York Sea Grant Extension Program. 12 pp.

Madenjian, C. P., and S. W. Gabray. 1994. **Walleye Consume More Fish than Do Birds in the Western Lake Erie Ecosystem.** Natl. Biol. Surv. Res. Inform. Bull. 53, 2 pp.

The 13,368 tonnes of fish estimated to have been consumed by over five species of waterbirds (9.3% by double-crested cormorants) is just 15% of the 88,200 tonnes of fish estimated to be eaten by walleyes between May and November of an average year.

Ross, R. M., and J. H. Johnson. 1994. **Feeding ecology of double-crested cormorants in eastern Lake Ontario.** Paper presented at joint annual meeting of the NY chapters of The Wildlife Society and the American Fisheries Society, January 26-28, Owego, New York. (Abstract only).

Based on analysis of remains in regurgitated pellets collected at Little Galloo Island (982 in 1992 and 1,307 in 1993), the authors found that "Alewife (*Alosa pseudoharengus*) were the dominant prey species in both 1992 (41% of all individuals) and 1993 (26%). Yellow perch (*Perca flavescens*) replaced centrarchids as the second most abundant prey category in 1993 (16% and 12%) versus 1992 (7% and 14%). Among game species, smallmouth bass (*Micropterus dolomieu*) comprised only 1% of prey fish in both years, while salmonid consumption was less than 1% in both years... Highest ranking mean numbers of fish per pellet by species or family group were alewife (2.4), centrarchids (0.8), and trout perch (0.6) in 1992 and alewife (3.2), yellow perch (1.9), and centrarchids (1.5) in 1993. Salmonids averaged less than 0.1 fish per pellet both years. The estimation of total fish losses in 1993 due to cormorant predation in eastern Lake Ontario was 0.975 million kg (2.15 million lbs) of fish, 55% of the quantity estimated by Weseloh and Casselman for 1991. An estimate of losses of lake trout (*Salvelinus namaycush*) from a stocking at Stony Point, New York, on 25 May 1993 was 2,623 fish, or 3.4% of the fish stocked. This estimate was made possible by recovery of 32 coded wire tags (1 per fish) from 176 pellets collected at Little Galloo Island the day after stocking. An additional 28 coded wire tags recovered from other stocking events or locations indicates an additional 2,295 stocked lake trout were eaten."

Weseloh, D. V., and J. M. Casselman. 1994. **Fish Consumption by Double-crested**

**Cormorants on Lake Ontario.** Unpublished manuscript, 16 pp.

Weseloh, D. V. C., and P. J. Ewins. 1994. **Characteristics of a rapidly increasing colony of double-crested cormorants (*Phalacrocorax auritus*) in Lake Ontario: population size, reproductive parameters, and band recoveries.** J. Great Lakes Res. 20: 443-456.

"Large alewife [*Alosa pseudoharengus*] (median length 15 cm) predominate in the diet of nestling double-crested cormorants in the outlet basin of Lake Ontario, and alewife, yellow perch (*Perca flavescens*), and various Centrarchid species appear to be the main diet of adult cormorants there (J. Neuman unpubl. data)."

### 1995

Brugger, K. E. 1995. **Double-crested cormorants and fisheries in Florida.** Colonial Waterbirds 18 (Spec. Publ. 1): 110-117.

Losses of food fish, primarily catfish, can be locally severe. Several hatcheries sustained high losses of fingerlings and stockers in recent years (game fish such as striped bass). Although sport anglers recently voiced concern over cormorants, no data are available from man-made lakes or conservation areas in Florida to document the food habits of double-crested cormorants to offer insight into the issue. Fish-eating birds were also reported to be a problem to growers of tropical fish.

Glahn, J. F., and A. R. Stickley Jr. 1995. **Wintering double-crested cormorants in the Delta region of Mississippi: population levels and their impact on the catfish industry.** Colonial Waterbirds 18 (Spec. Publ. 1): 137-142.

The foraging rate of a typical flock of 30 cormorants averaged 5 catfish per cormorant-hour. In a number of cases, however, cormorants using ponds appeared to be primarily feeding on, and appeared to prefer, Gizzard shad (*Dorosoma cepedianum*) that proliferate in these ponds.

Glahn, J. F., and K. E. Brugger. 1995. **The impact of double-crested cormorants on the Mississippi Delta catfish industry: a bioenergetics model.** Colonial Waterbirds 18 (Spec. Publ. 1): 168-175.

"A bioenergetics model was constructed and evaluated for estimating Double-crested Cormorant energy expenditures, food demand and impact on the Channel Catfish industry in the Delta region... Factoring in population sizes and proportional intake of catfish, [cormorants] may have eaten up to 20 million catfish per winter in 1989-90 and 1990-91 or approximately 4% of the estimated standing crop."



Glahn, J. F., P. J. Dixon, G. A. Littauer, and R. B. McCoy. 1995. **Food habits of double-crested cormorants wintering in the Delta region of Mississippi.** Colonial Waterbirds 18 (Spec. Publ. 1): 158-167.

The diet of double-crested cormorants wintering in the Delta region of Mississippi was studied from collections of 202 birds taken at catfish farms and 461 birds taken at night roost sites. Channel catfish (*Ictalurus punctatus*) and Gizzard shad (*Dorosoma cepedianum*) were the only two important prey species, comprising >90% of the diet from all samples. Overall, the diet was approximately equal between catfish and shad.

Kirsch, E. M. 1995. **Double-crested cormorants along the Upper Mississippi River.** Colon. Waterbirds 18 (Spec. Publ. 1): 131-136.

"Of the 17 adult and juvenile cormorants collected, four contained no recognizable fish parts in their esophagus or stomach, 12 contained remains of one to seven Gizzard Shad (*Dorosoma cepedianum*), and one contained one White Bass (*Morone chrysops*)..." The mean length of Gizzard Shad was 13.1 cm. Chicks regurgitated fish remains representing at least eight species: Gizzard Shad, Golden Shiner, Bluegill, Common Carp, Largemouth Bass, redbreast, White Bass, and Channel Catfish.

Madenjian, C. P., and S. W. Gabrey. 1995. **Waterbird predation on fish in western Lake Erie: a bioenergetics model application.** Condor 97: 141-153.

Modeling results indicate that, during the early 1990s, nine species of fish-eating waterbirds consumed 13,368 tonnes of fish from western Lake Erie each year. This consumption represented 11.4% of the total prey fish biomass (117,600 tonnes) needed to support the walleye (*Stizostedion vitreum*) population on an annual basis. The double-crested cormorant nesting population in western Lake Erie consumed 1,244 tonnes of fish, which was 9.3% of the total fish predation by birds in the western basin, and 1.1% of the total prey fish biomass needed to support the walleye population on an annual basis. "Presently, there may be some concern that if the cormorant population were to continue to increase, the prey fish base for walleye in western Lake Erie would be in jeopardy. Yet, if the nesting cormorant population doubled in size while populations of the other waterbirds remained constant, total fish consumption by piscivorous waterbirds from western Lake Erie would only show a modest increase from 13,368 to 14,612 [tonnes] or just 9.3%."

Ross, R. M., and J. H. Johnson. 1995. **Preliminary Analysis of 1994 Double-crested Cormorant Pellets from Little Galloo Island.** Unpublished Admin. Report, Natl. Biol. Serv., Wellsboro, Pennsylvania. 1 p.

Analysis of 1,538 pellets collected on ten dates, 4 May-7 July, revealed presence of 21 fish prey species. The top four species were yellow perch (25% of individuals), trout-perch (17%), sunfishes (16%), and alewives (16%).

Salmonids (all lake trout) represented just 0.1% of the prey items.

"Only nine coded wire tags were recovered from cormorant pellets in 1994, all on June 7. Eight of the nine recoveries were from fish stocked on June 3 at Stony Point. From a known total stocking of 117,000 lake trout at Stony Point on June 3, a known pellet collection on June 7 of 155 pellets, and an estimated adult cormorant population of 7,490... we estimate a total of 515 lake trout eaten from the stocking event (0.44%)."

Ross, R. M., and J. H. Johnson. 1995. **Seasonal and annual changes in the diet of double-crested cormorants: implications for Lake Ontario's fishery.** Great Lakes Res. Rev. 2: 1-9.

Simmonds, R. L., Jr., A. V. Zale, and D. M. Leslie Jr. 1995. **Effect of Piscivorous Birds, Particularly Cormorants, on Reservoir and Aquacultural Fishes in Oklahoma.** Final Report prepared by Oklahoma Coop. Fish Wildl. Research Unit for U.S. Fish & Wildlife Serv., Albuquerque, New Mexico.

Weseloh, D. V., P. J. Ewins, J. Struger, P. Mineau, C. A. Bishop, S. Postupalsky, and J. P. Ludwig. 1995. **Double-crested cormorants of the Great Lakes: changes in population size, breeding distribution, and reproductive output between 1913 and 1991.** Colonial Waterbirds 18 (Spec. Publ. 1): 48-59.

"On the Great Lakes, double-crested cormorants appear to eat a wide range of fish species, usually about 15 cm long, but up to 30 cm (J. Neuman unpubl.). Alewife (*Alosa pseudoharengus*), yellow perch (*Perca flavescens*), and various centrarchid species were the most common foods in the diet of adults and young in a recent study in eastern Lake Ontario (J. Neuman unpubl. data)." Alewife have a relatively high caloric content, "and may be the preferred prey. In eastern Lake Ontario, alewife is now the main prey of cormorants during the breeding season." The recent increase in cormorant nesting populations on the Great Lakes (29%/year since the early 1970s) "is steeper than in most other parts of the species' range, and is attributed to a combination of factors: reduced human persecution, declining levels of organochlorine contaminants, and an abundance of forage-base fish, notably alewife (*Alosa pseudoharengus*), following decimation of Great Lakes stocks of predatory fish between the 1940s and 1960s, which has been attributed to predation by sea lampreys (*Petromyzon marinus*) and human over-exploitation."

## 1996

Johnson, J. H., and R. M. Ross. 1996. **Pellets versus feces: their relative importance in describing the food habits of double-crested cormorants.** J. Great Lakes Res. 22: 795-798.

## 1997

Blackwell, B. F., and W. B. Krohn. 1997. **Spring foraging distribution and habitat selection by double-crested cormorants on the Penobscot River, Maine, USA.** Colonial Waterbirds 20: 66-76.

Blackwell, B. F., W. B. Krohn, N. R. Dube, and A. J. Godin. 1997. **Spring prey use by double-crested cormorants on the Penobscot River, Maine, USA.** Colonial Waterbirds 20: 77-86.

Diana, J.S., G.Y. Belyea, and R.D. Clark Jr. (Eds.). 1997. **History, status, and trends in populations of yellow perch and double-crested cormorants in Les Cheneaux Islands, Michigan.** Michigan Dep. Nat. Resour. Fish. Div. Spec. Rep. 17. 94pp.

Hill, S.J., D.K. Cairns, C. Ripley, B. Penak, and K. Arsenault. 1997. **Numbers and diets of double-crested cormorants on the Dunk River in spring of 1993 and 1995.** Prince Edward Island Tech Rep. Environ. Sci. No. 3.

Neuman, J., D.L. Pearl, P.G. Ewins, R. Black, D.V. Weseloh, M. Pike, and K. Karwowski. 1997. **Spatial and temporal variation in the diet of double-crested cormorants (*Phalacrocorax auritus*) breeding on the lower Great Lakes in the early 1990s.** Can. J. Fish. Aquat. Sc. 54: 1569-1584.

## 1998

Cairns, D.K. 1998. **Diet of cormorants, mergansers, and kingfishers in northeastern North America.** Canadian Tech. Rep. of Fisheries and Aquatic Sciences No. 2225.

A review of diet studies in the Atlantic region, spanning 1915-97; found that commercial and recreational species averaged 73% of reported prey composition during the smolt run, and 44% outside the smolt run.

Glahn, J.F., J.B. Harrel and C. Vyles. 1998. **The diet of wintering double-crested cormorants feeding at lakes in the southeastern United States.** Colonial Waterbirds 21(3): 446-452.

Rail, J. and G. Chapdelaine. 1998. **Food of double-crested cormorants, *Phalacrocorax auritus*, in the gulf and estuary of the St. Lawrence River, Quebec, Canada.** Can. J. Zool. 76: 635-643.

## 1999

Johnson, J.H., R.M. Ross, and C.M. Adams. 1999. **Diet composition and fish consumption of double-crested cormorants in eastern Lake Ontario, 1998.** New York State Department of Environmental Conservation Special Report. February 1, 1999.

The diet of double-crested cormorants in eastern Lake Ontario was described by identifying diagnostic remains found in regurgitated pellets collected on Little Galloo Island. Pellets were collected weekly from mid-April to late September, 1998. Sample size was 150. Substantial variation occurred among months in diet composition and daily fish consumption. Alewife (*Alosa pseudoharengus*) were the major prey of cormorants (27%), but represented <10% of the diet during some months. Three-spine stickleback (*Gasterosteus aculeatus*) represented 21.6% of the fish eaten based largely on their dominance in the diet in May (50.9%). In other months, sticklebacks did not exceed 5.0% of the diet. Yellow perch (*Perca flavescens*), the third most abundant prey in the diet over the six month period. Pumpkinseed (*Lepomis gibbosus*) and rock bass (*Ambloplites rupestris*) collectively made up 9% of the cormorant diet. Gamefish made up 1.6% of the diet, comprised of mainly smallmouth bass (*Micropterus dolomieu*).

Lantry, B.F., T.H. Eckert and C.O. Schneider. 1999. **The relationship between the abundance of smallmouth bass and double-crested cormorants in the eastern basin of Lake Ontario.** New York State Department of Environmental Conservation Special Report. February 1, 1999.

Calculated the percent of 3-5 year old smallmouth bass preyed upon by cormorants in the eastern basin, and estimated that cormorant predation reduced the 3-5 year old age group by 23% in 1993-4, and by 36% in 1998. Reported that (1) the mortality of age-3 to 5 smallmouth bass increased substantially after 1988; (2) loss rates of the magnitude reported above could severely limit numbers of adult stock recruited to the fishery; and (3) cormorant predation on 3-5 year old age classes was substantial enough to cause the observed declines in the smallmouth bass population.

Van De Valk, A.J., L.G. Rudstam, T. Brooking, and A. Beitler. 1999. **Walleye stock assessment and population projections for Oneida Lake, 1998-2001.** New York Federal Aid Study VII, Job 103. FA-5-R.

Described cormorant diet composition by percent number and percent biomass. Found that double-crested cormorants consumed less than 1% of yellow perch in Oneida Lake, most of which were 0-1 year olds. Cormorants consumed less than 1% of walleye, 43% of which were 0-1 year olds and 57% of which were age 2-3 or older. Cormorants consumed 100,600 walleye aged 1 year and older, with a mortality rate due to cormorant predation estimated to be 12-20%.

2000

Belyea, G.Y., S.L. Maruca, J.S. Diana, P.J. Schneeberger, S.J. Scott, R.D. Clark, and J.P. Ludwig. In Press. **Impact of double-crested cormorant predation on the yellow perch population in the Les Cheneaux Islands of Michigan.**

Estimated that cormorants removed 1% of the legal size yellow perch population in 1995, while angler exploitation removed 2.4%. Cormorant predation accounts for a greater proportion of mortality at younger ages (fish aged 1-3 years), while anglers essentially take age 3 and older perch.

Bur, M.T., S.L. Tinnirello, C.D. Lovell and J.T. Tyson. In Press. **Diet of the double-crested cormorant in western Lake Erie.**